Claims

1. An inkjet printhead having a series of nozzles for the ejection of ink wherein each said nozzle has a rim formed by the deposition of a rim material layer over a sacrificial layer and a subsequent planar removal of at least said rim material layer so as to form said nozzle rim.

2. An inkjet printhead as claimed in claim 1 wherein said planar removal comprises chemical - mechanical planarization of said rim material layer.

3. An inkjet printhead as claimed in claim 2 wherein parts of said sacrificial layer are also removed by said planar removal.

4. An inkjet printhead as claimed in claim 1 wherein said planar removal process is an etching process.

5. An inkjet printhead as claimed in claim 1 wherein said rim material layer comprises TEOS glass.

6. An inkjet printhead as claimed in claim 1 wherein said rim material layer is PECVD Si_3N_4.

7. An inkjet printhead as claimed in claim 1 wherein said rim material layer is MOCVD TiN.

8. An inkjet printhead as claimed in claim 1 wherein said rim material layer is ECR CVD TiN.

9. An inkjet printhead comprising:

a plurality of nozzle chambers each having an ink ejection aperture in one wall thereof and an actuator interconnection aperture in a second wall thereof;

a moveable ink ejection paddle located within the nozzle chamber and moveable under the control of an external thermal actuator through said actuator interconnection aperture for the ejection of ink out of said ink ejection aperture;

said external actuator being covered by a protective covering shell around the operational portions of said actuator, spaced apart from said actuator.

10. An inkjet printhead as claimed in claim 9 wherein said protective covering shell is formed simultaneously with the formation of other portions of said inkjet printhead.

11. An inkjet printhead as claimed in claim 10 wherein said protective covering shell is formed simultaneously with said walls of said nozzle chamber.

12. An inkjet printhead as claimed in claim 10 wherein said protective covering shell is formed by deposition and etching of a sacrificial material layer followed by deposition and etching of an inert material layer forming said protective covering shell.

13. An inkjet printing arrangement as claimed in claim 10 wherein said external actuator

comprises a thermal bend actuator.

14. A method of forming an inkjet printhead on a substrate, said method including:

providing a first substrate in which is formed electrical drive circuitry made up of layers of conductive, semi-conductive and non-conductive materials for the control of said inkjet printhead;

forming on said substrate at least one nozzle chamber having an ink ejection aperture in a wall thereof and ink ejection means to eject the ink from said aperture;

wherein portions of at least one of said layers of said first substrate are utilized as a sacrificial material layer in the formation of at least part of said ink ejection means.

15. A method as claimed in claim 14 wherein said ink ejection means comprises a moveable ink ejection paddle within said nozzle chamber, moveable under the control of an actuator for the ejection of ink from said aperture.

16. A method as claimed in claim 14 wherein said sacrificial material layer comprises portions of a conductive layer of said electrical drive circuitry.

17. A method as claimed in claim 16 wherein said electrical drive circuitry comprises a Complementary Metal Oxide Semiconductor (CMOS) process.

18. A method as claimed in claim 16 wherein said sacrificial material layer comprises a CMOS metal layer.

19. A method as claimed in claim 15 wherein said actuator comprises a thermal actuator.

20. A method as claimed in claim 15 wherein said actuator is located external to said nozzle chamber and is interconnected to said ink ejection paddle through an actuation interconnection aperture formed in a second wall of said nozzle chamber.

21. An inkjet printhead constructed by MEMS processing techniques with a plurality of ink ejection nozzles each having a nozzle chamber, an external thermal bend actuator having a proximal end anchored to a substrate and a distal end connected to an ink ejection paddle within said chamber;

wherein said external thermal bend actuator further comprises a series of layers and includes a planar conductive heating circuit layer which includes a first portion adjacent said proximal end forming a planar conductive heating circuit for heating said thermal bend actuator, and a second portion extending to said ink ejection paddle, said second portion being electrically isolated from said first portion by means of a discontinuity in said planar conductive heating circuit layer, said discontinuity being located external to said nozzle chamber.

22. An inkjet printhead as claimed in claim 21 wherein said discontinuity comprises a slot extending across the thermal bend actuator.

23. An inkjet printhead as claimed in claim 21 wherein said planar conductive heating circuit layer comprises substantially titanium nitride.

24. An inkjet printhead as claimed in claim 21 wherein said conductive circuit includes at least one tapered portion adjacent said proximal end arranged to increase resistive heating adjacent said proximal end.

25. An inkjet printhead having a series of ink ejection nozzles for the ejection of ink, each of said nozzles interconnecting a nozzle chamber with an external atmosphere, each said nozzle having a first meniscus rim around which an ink meniscus normally forms, and an extended ink flow prevention rim spaced outwardly from said first meniscus rim and substantially encircling said first meniscus rim, arranged to prevent the flow of ink across the surface of said inkjet printhead.

26. An inkjet printhead as claimed in claim 25 wherein said first meniscus rim and said extended ink flow prevention rim are spaced apart by a pit arranged to contain ink.

27. An inkjet printhead as claimed in claim 25 wherein said ink flow prevention rim is substantially co-planar with said first meniscus rim.

28. An inkjet printing arrangement as claimed in claim 25 wherein said ink flow prevention rim is formed from the same material as said first meniscus rim.

29. An inkjet printing arrangement as claimed in claim 25 wherein said ink flow prevention rim and said first meniscus rim are formed utilizing chemical mechanical planarization.

30. An inkjet printing arrangement as claimed in claim 25 wherein said ink flow prevention rim and said first meniscus rim are formed from PECVD TEOS.

31. An inkjet printing arrangement as claimed in claim 25 wherein said ink flow prevention rim and said first meniscus rim are formed from silicon nitride.

32. A method of forming a moveable micromechanical device including a bend actuator adapted to curve in a first bending direction along a bending axis, said method comprising the steps of:

forming a substrate comprising a series of structures formed in a plurality of deposited lower layers, said substrate having a predetermined upper surface profile; and forming said bend actuator on said upper surface of said substrate so as to bend in a direction away and toward therefrom.

33. A method according to claim 32 including the step of planarizing said upper surface to achieve a substantially flat surface prior to forming said bend actuator.

34. A method according to claim 32 for forming a device having a plurality of said bend actuators, said method including the step of configuring said series of structures formed in said plurality of lower layers so as to be identical under each actuator.

35. A method according to claim 32 wherein said structures in said lower layers are configured such that corrugations arising therefrom in said upper surface profile of said substrate extend in a direction that is substantially transverse to the bending axis of said actuator.

36. A method as claimed in claim 32 wherein said bend actuator comprises a thermal bend actuator.

37. A method as claimed in claim 32 wherein said deposited layers include a conductive circuitry layer.

38. A method as claimed in claim 37 wherein said conductive circuitry layer is interconnected to said bend actuator for activation of said bend actuator.

39. A method as claimed in claim 32 wherein said bend actuator is attached to a paddle member within a nozzle chamber and actuated for the ejection of ink from an ink ejection nozzle of an inkjet printhead.

40. A method as claimed in claim 37 wherein said deposited layer, located under said bend actuator include a power transistor for the control of operation of said bend actuator.

41. A method of construction of an inkjet printhead having a large array of inkjet nozzle arrangements said method comprising:

defining a single inkjet nozzle arrangement for the ejection of ink from a single nozzle; and

utilizing a series of translations and rotations of said single inkjet nozzle arrangement to form all the inkjet nozzles of said inkjet print head;

said utilizing step including:

initially forming a plurality of nozzles in a pod;

forming a group of pods, each group corresponding to a different colored ink dispensed from said printhead;

forming a plurality of said groups of pods into a firing group;

combining firing groups forming a segment of said printhead;

forming each segment together to form said printhead.

42. A method as claimed in claim 41 wherein said inkjet nozzle arrangements include a series of layers deposited and etched utilizing a mask.

43. A method as claimed in claim 42 wherein said layers include conductive layers which are etched utilizing said mask so as to form a series of conductive interconnections.

44. A method as claimed in claim 43 wherein said conductive interconnections include interconnections with adjacent versions of said inkjet nozzle arrangement which comprise translated and/or rotated copies of said inkjet nozzle arrangement.

45. A method as claimed in claim 41 wherein said printhead is constructed from a series of segment replications.

46. A method of operation of a fluid ejection printhead within a predetermined thermal range so as to print an image, said printhead including a series of thermal actuators operated to eject fluid from said printhead, said method comprising the steps of:

(a) sensing the printhead temperature of said printhead to determine if said printhead temperature is below a predetermined threshold,

(b) if said printhead temperature is below said predetermined threshold, performing a preheating step of heating said printhead so that it is above said predetermined threshold,

(c) controlling said preheating step such that said thermal actuators are heated to an extent insufficient to cause the ejection of fluid from said printhead; and

(d) utilizing said printhead to print said image.

47. A method as claimed in claim 46 further comprising the steps of:

(a) initially sensing an ambient temperature surrounding said printhead;

(b) setting said predetermined threshold to be said ambient temperature plus a predetermined operational factor amount, said operational factor amount being dependant on said ambient temperature.

48. A method as claimed in claim 46 further comprising the step of:

(e) monitoring said printhead temperature whilst printing said image and where said temperature falls below said predetermined threshold, reheating said printhead so that it is above said predetermined threshold.

49. A method as claimed in claim 46 wherein said step (b) comprises constantly monitoring said printhead temperature whilst heating said printhead.

50. A method as claimed in claim 47 wherein said step (c) further comprises applying a series of short electrical pulses to said thermal actuators, each being insufficient to cause the ejection of fluid from said printhead.

51. A fluid ejection device comprising:

an array of nozzles formed on a substrate and adapted to eject ink on demand by means of a series of ink ejection thermal actuators actuated by an actuator activation unit attached to said ink ejection actuators for activation thereof;

at least one temperature sensor attached to said substrate for sensing the temperature of said substrate; and

a temperature sensor unit;

wherein before a fluid ejection operation is begun said temperature sensor unit utilizes said at least one temperature sensor to sense a current temperature of said substrate, and if said temperature is below a predetermined limit, to output a preheat activation signal to said actuator activation unit, whereupon said actuator activation unit activates said ink ejection thermal actuators to an extent sufficient to heat said substrate, while being insufficient for the ejection of ink from said array.

52. A fluid ejection device as claimed in claim 51 wherein said at least one temperature sensor comprises a series of spaced apart temperature sensors formed on said printhead.

53. A fluid ejection device as claimed in claim 51 wherein said array of nozzles are divided into a series of spaced apart segments with at least one temperature sensor per segment.

54. An ink supply arrangement for supplying ink to the printing arrangement of a portable printer, said ink supply arrangement including:

an ink supply unit including at least one storage chamber for holding ink for supply to said printing arrangement, said ink supply unit including a series of spaced apart baffles configured so as to reduce the acceleration of the ink within the unit as may be induced by movement of the portable printer, whilst allowing for flows of ink to the printing arrangement in response to active demand therefrom.

55. An ink supply arrangement according to claim 54, wherein the ink printing arrangement is in the form of a printhead which is connected directly to an ink supply arrangement in the form of an ink supply unit having an ink distribution manifold that supplies ink via a plurality of ink outlets to corresponding ink supply passages formed on the printhead.

56. An ink supply arrangement according to claim 54, wherein the printhead is an elongate pagewidth printhead and the baffles in the ink supply unit are configured to reduce acceleration of the ink in a direction along the longitudinal extent of the printhead and corresponding ink supply unit.

57. An ink supply arrangement according to claim 54, wherein the ink supply unit has a series of storage chambers for holding separate color inks.

58. An ink supply arrangement according to claim 54, wherein the printing arrangement is in

the form of a printhead chip.

59. An ink supply arrangement according to claim 54 or claim 57, wherein the ink storage chamber or chambers are constructed from molded components.

60. An ink supply arrangement according to claim 59, constructed from two or more interconnecting molded components.

61. An ink supply arrangement according to claim 60, configured to define three or more separate ink storage chambers having baffles disposed therein.

62. An ink supply arrangement according to claim 56, wherein at least some of the baffles extend in directions transverse to the longitudinal extent of the printhead.

63. An ink supply arrangement according to claim 59 or claim 60, wherein said components are injection molded.

64. An ink supply arrangement according to claim 61, made up from an ink distribution manifold, a baffle unit and a housing, which together define an ink unit having three or more separate ink storage chambers having baffles disposed therein.

65. An ink supply arrangement according to claim 64, including a series of piercable wall portions for connection thereto of an ink supply conduit connecting to a bulk ink supply source.

66. An ink supply arrangement according to claim 54, including a series of hydrophobically sealed breather holes.

67. An ink supply unit including a series of molded chambers for holding separate color inks for supply to a portable ink jet printing arrangement, said ink supply unit including:

a series of spaced apart baffles formed within said molded chambers so as to restrict high speed fluid flow within said molded chambers whilst simultaneously allowing low velocity flows through said molded chambers.

68. An ink supply unit as claimed in claim 66, wherein said molded chambers are formed through the injection molding of at least two separate parts which are sealed together to form said ink supply unit.

69. A power distribution arrangement for an elongate inkjet printhead of a kind having a plurality of longitudinally spaced voltage supply points, said power distribution arrangement including:

two or more elongate low resistance power supply busbars; and

interconnect means to connect a selected plurality of said voltage supply points to said busbars.

70. A power distribution arrangement according to claim 69 wherein said busbars are disposed to extend parallel to said printhead and said interconnect means provide interconnections extending generally transversely therebetween.

71. A power distribution arrangement according to claim 69 wherein said interconnect means is in the form of a tape automated bonded film (TAB film).

72. A power distribution arrangement according to claim 71 wherein said TAB film electrically connects with said busbars by means of correspondingly sized noble metal deposited strips formed on said TAB film.

73. A power distribution arrangement according to claim 69 wherein said interconnect means also includes a plurality of control lines for connection to selected other of said voltage supply points on said printhead.

74. A power distribution arrangement according to claim 69 wherein said flexible interconnect means is in the form of one or more printed circuit boards which connect directly to said busbars, with wire bonds connecting the printed circuit boards to said printhead.

75. A power distribution arrangement according to claim 69 wherein said interconnect means is configured so that it need only be connected to said printhead along one edge thereof.

76. A power distribution arrangement according to claim 71 wherein a double sided TAB film is used having power interconnect means on the one side for connection between said busbars and printhead, and control line interconnect means on the other of said sides for connection of the printhead to corresponding external control lines.

77. A power distribution arrangement according to claim 73 or claim 76 wherein said control line interconnect means are also repeatedly connected with said power supply busbars.

78. A power distribution arrangement according to claim 69 wherein the printhead is in the form of a printhead chip manufactured by a MEMS processing technique.

79. A power distribution arrangement according to claim 78 wherein said printhead utilises a thermal bend actuator device for ejection of ink from a plurality of corresponding nozzles formed in the printhead.

80. A power distribution arrangement according to claim 69 wherein said low resistance busbars and flexible interconnect means are packaged with an associated ink supply unit for delivering ink to ink supply passages formed in said printhead.

81. A power distribution arrangement according to claim 80 wherein said ink supply unit includes:

a slot for insertion of said printhead;

a series of elongated chambers for the storage of separate color inks, said chambers being interconnected with said slot for the supply of ink to said printhead;

said busbars being connected along said ink supply unit;

the interconnect means being in the form of a tape automated bonding strip similarly disposed along the outside of said ink supply unit having a series of control lines along one surface thereof for mating with corresponding external series of control lines, said tape automated bonding strip further having a repeating series of interconnects to said printhead, said interconnects interconnecting said control lines and said busbars to said printhead.

82. A power distribution arrangement according to claim 73 or claim 81 wherein said ink supply unit is detachable from said power supply and said external series of control lines.

83. A power distribution arrangement according to claim 69 wherein said busbars comprise two mechanically stiff conductive rails.

84. A power distribution arrangement according to claim 69 wherein said interconnect means includes a flexible portion that connects with said printhead.

85. A power distribution arrangement according to claim 81 wherein said ink supply unit includes a series of positioning protuberances for accurately locating the power supply busbars and/or interconnect means therewith.

86. An ink supply unit for supplying a printhead containing an array of ink ejection nozzles, said supply unit comprising:

a first member formed having dimensions refined to a first accuracy and having a first cavity defined therein;

a second member in the form of an ink distribution manifold having a second cavity defined therein, said second cavity being adapted for the insertion of a printhead;

said second member being configured to engage said first cavity in said first member so as to define one or more chambers for the supply of ink to ink supply passages formed in said printhead;

said second member being formed having dimensions refined to a second accuracy which is higher than said first accuracy.

87. An ink supply unit according to claim 86, including a screen for filtering said ink supply flowing through to said printhead.

88. An ink supply unit according to claim 86, wherein said first and/or second members include baffles to reduce acceleration of the ink within the ink supply unit.

89. An ink supply unit according to claim 86, wherein said first and second members are configured to together define an ink supply unit having series of ink storage chambers.

90. An ink supply unit according to claim 86, wherein said second member defines a series of discrete ink outlets configured to supply ink to ink supply passages provided in said printhead that are adapted to provide ink to grouped sets of ink ejection nozzles.

91. An ink supply unit according to claim 86, configured to define a series of chambers for the storage of separate colour inks for supply to a multiple colour printhead.

92. An ink supply unit according to claim 86, configured to supply ink to a printhead in the form of a printhead chip.

93. An ink supply unit according to claim 86, configured for a pagewidth printer.

94. An ink supply unit according to claim 86, wherein said second member is connected to said first member by means of a resilient adhesive.

95. An ink supply unit according to claim 86, wherein the second member has overall external dimensions that are substantially smaller than the overall external dimensions of the first member.

96. An ink supply unit for supplying a multiple color pagewidth ink supply printhead, comprising:

a first elongated member containing a series of chambers for the storage of separate color inks and formed having dimensions refined to a first accuracy and having a first elongated cavity defined therein;

a second elongated member including a series of wall elements and a second elongated cavity defined therein, said second elongated cavity being adapted for the insertion of a pagewidth ink jet printhead, said wall elements mating with corresponding elements of said first elongated member to complete the formation of said series of chambers for the supply of ink to a series of slots formed in the back of said printhead when inserted in said second elongated cavity, wherein said second elongate member is formed having dimensions refined to a second accuracy which is higher then said first accuracy.

97. A method of interconnecting a printhead containing an array of ink ejection nozzles to an ink distribution manifold, said method comprising:

attaching said printhead to said ink distribution manifold utilizing a resilient adhesive adapted to be elastically deformed with any deflections of the ink distribution manifold.

98. A method as claimed in claim 97 wherein said printhead has an elongate structure and a corresponding printhead aperture is provided in the ink distribution manifold wherein the printhead is attached to the ink distribution manifold along the sides and a back surface of the printhead.

99. A method as claimed in claim 97 wherein said printhead is in the form of a printhead

chip.

100. A method as claimed in claim 99 wherein said printhead chip is in the form of a thermal bend actuator type device produced by micro-electromechanical processing techniques for mechanical ejection of ink from discrete nozzle chambers.

101. A method according to claim 98 wherein said printhead is a pagewidth printhead.

102. A method according to claim 97 wherein said ink distribution manifold forms part of an ink supply unit that is distinct from a bulk ink storage means.

103. A method according to claim 102 wherein said printhead is in the form of a pagewidth printhead chip containing a linear array of ink ejection nozzles and said ink supply unit has a series of chambers for the supply of separate color inks to said printhead chip.

104. A method according to claim 103 wherein said ink supply unit comprises:

a first elongated member containing a series of chambers for the storage of separate color inks and having a first elongated cavity defined therein;

a second elongated member including a series of wall elements and a second elongated cavity defined therein, said second elongated cavity being adapted for the insertion of a page width ink jet printhead, said wall elements mating with corresponding elements of said first elongated member to complete the formation of said series of chambers for the supply of ink to a series of slots formed in the back of said printhead when inserted in said second elongated cavity,

wherein said second elongated member is interconnected to said fist elongated member utilizing a resilient adhesive adapted to be elastically deformed with any bending of said ink supply unit.

105. A method according to claim 97 or claim 104 wherein said resilient adhesive is a silicone elastomer.

106. A printhead and ink distribution manifold assembly wherein said printhead is attached to said ink distribution manifold by means of a resilient adhesive adapted to be elastically deformed with any deflections of the ink distribution manifold.

107. A printhead and ink distribution manifold assembly according to claim 106 wherein said printhead has an elongate structure and a corresponding printhead aperture is provided in the ink distribution manifold, wherein the printhead is attached to the ink distribution manifold along the sides and a back surface of the printhead.

108. A printhead and ink distribution manifold assembly according to claim 106 wherein said printhead is in the form of a printhead chip.

109. A printhead and ink distribution manifold assembly according to claim 108 wherein said

printhead chip is in the form of a thermal bend actuator type device produced by micro-electromechanical processing techniques for mechanical ejection of ink from discrete nozzle chambers.

110. A printhead and ink distribution manifold assembly according to claim 107 wherein said printhead is a pagewidth printhead.

111. A printhead and ink distribution manifold assembly according to claim 106 wherein said ink distribution manifold forms part of an ink supply unit.

112. A printhead and ink distribution manifold assembly according to claim 111 wherein said printhead is in the form of a pagewidth printhead chip containing a linear array of ink ejection nozzles and said ink supply unit has a series of chambers for the supply of separate color inks to said printhead chip.

113. A printhead and ink distribution manifold assembly according to claim 112 wherein said ink supply unit comprises:

a first elongated member containing a series of chambers for the storage of separate color inks and having a first elongated cavity defined therein;

a second elongated member including a series of wall elements and a second elongated cavity defined therein, said second elongated cavity being adapted for the insertion of a page width ink jet printhead, said wall elements mating with corresponding elements of said first elongated member to complete the formation of said series of chambers for the supply of ink to a series of slots formed in the back of said printhead when inserted in said second elongated cavity,

wherein said second elongated member is interconnected to said fist elongated member utilizing a resilient adhesive adapted to be elastically deformed with any bending of said ink supply unit.

114. A printhead and ink distribution manifold assembly according to claim 106 or claim 113 wherein said resilient adhesive is a silicone elastomer.

115. An inkjet printhead comprising:

a plurality of nozzle chambers, each having a nozzle aperture defined in one wall thereof for the ejection of ink out of said aperture;

an ink supply channel interconnected with said nozzle chamber;

a paddle moveable within the nozzle chamber by an actuator and operable to eject ink from said nozzle chamber, said paddle having a projecting part which, upon operation of said actuator is caused to move towards said nozzle aperture.

116. An inkjet printhead as claimed in claim 115 wherein said projecting part, upon operation of said actuator, moves through the plane of said aperture.

117. An inkjet printhead as claimed in claim 115 wherein said projecting part is located concentrically with said nozzle aperture.

118. An inkjet printhead as claimed in claim 115 wherein said liquid ejection aperture is formed by MEMS process utilizing the deposition and etching of a series of layers and said projecting part comprises a hollow cylindrical column.

119. An inkjet printhead as claimed in claim 118 wherein said hollow cylindrical column includes a proximal end at the paddle and a distal end adjacent said aperture, said distal end being chemically mechanically planarized during the formation of said aperture.

120. An inkjet printhead as claimed in claim 115 wherein said actuator comprises a thermal bend actuator conductively heated so as to cause movement of said paddle.

121. An inkjet printhead as claimed in claim 115 wherein said projecting part is located substantially centrally on said paddle.

122. In an inkjet printhead having at least one chamber from which liquid is ejected from a nozzle aperture interconnected with said chamber by means of movement of a liquid ejection paddle, a method of improving the operational characteristics of said printhead comprising the steps of:

locating a projecting part on said moveable paddle, said projecting part undergoing movement towards said nozzle aperture upon activation of said liquid ejection paddle to eject fluid.

123. A method as claimed in claim 122 wherein said projecting part includes an end portion which moves through the plane of a rim of said aperture upon activation of said liquid ejection paddle.

124. A method as claimed in either claim 122 or claim 123 wherein said projecting part is arranged substantially concentrically with the nozzle aperture.

125. An inkjet printhead apparatus comprising:

a plurality of nozzle chambers each having a nozzle aperture defined in one wall thereof for the ejection of ink out of said chamber and a second aperture for the insertion of an actuator mechanism;

an ink supply channel interconnected with said nozzle chamber;

a paddle moveable by an actuator operable to eject ink from said nozzle chamber, said actuator including:

a first portion located externally of said nozzle chamber and

a second portion located internally of said nozzle chamber, supporting said paddle;

an interconnecting portion interconnecting said first portion and said second portion through said second aperture, said interconnecting portion further including a protruding shield formed adjacent said second aperture and positioned so as to restrict the flow of fluid through said second aperture.

126. An apparatus as claimed in claim 125 wherein said shield comprises a hydrophobic surface.

127. An apparatus as claimed in claim 125 wherein, in use, said interconnecting portion moves in an upwardly defined direction towards said liquid ejection aperture, and said shield is formed on an upper surface of said interconnecting portion.

128. An apparatus as claimed in claim 125 wherein said actuator includes a thermal expansion actuator.

129. An apparatus as claimed in claim 128 wherein said thermal expansion actuator is located in said first portion of said actuator.

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